ORDA Clutter Mapping

ORDA Systems Engineering

ABSTRACT

Good clutter mapping increases the effectiveness of clutter filtering. In the legacy RDA, clutter mapping is a slow process, requiring the antenna to stop before each data collection. The data is collected on a different radial scheme than that used operationally. ORDA will gather clutter mapping data with the antenna moving, and the clutter map will correlate to the radials gathered operationally. The scheme will provide the best mapping control for clutter closer to the radar, where clutter is more prevalent.

Introduction

Clutter mapping is designed to identify areas of clutter for clutter filtering. It provides a way to identify clutter and help separate clutter-like weather phenomena (e.g. stratiform rain) from actual clutter. Therefore, the map must be made on radar returns that can be accurately identified as clutter or weather to properly map them. This means making a clutter map when there are few weather related returns, and no returns from anomalous propagation or other radar artifacts.

The majority of clutter is close to the radar, where the beam is closer to the ground and has a higher power density. Clutter characteristics are zero velocity and a small spectrum width ($0.28 ms^{-1}$ spectrum width is assumed for ground clutter). It is normally much larger than weather returns. Clutter is also quite seasonal. Many factors affect ground clutter: ground moisture, vegetation cover, wind, construction, etc. This means that a clutter map must be updated occasionally to account for seasonal and man-made changes. An automated clutter map is typically run every 6 months.

Current automated clutter mapping is a slow, laborious process, taking at least 2 hours. ORDA automated clutter mapping will take less than 20 minutes.

Automated clutter mapping is not intended to map sea clutter well. Wave motion means sea clutter has a larger spectrum width, and varies greatly depending on atmospheric conditions.

Clutter Mapping Requirements

The NEXRAD System Specification (SS) contains no direct requirements for clutter mapping. There are 2 references that imply clutter mapping: 3.7.2.7.1 shall 3 (RDA section) and 3.7.3.4.16 shall 1 (RPG section). The sections of the SS requirements for clutter filtering follow:

3.7.2.7 Ground Clutter Suppression

The objective of the ground clutter suppression capability is to improve the measurement of weather return parameters in the presence of clutter. Clutter suppression is defined as the ratio of clutter input to clutter output, normalized to filter noise gain. Clutter suppression performance is described by the improvement in the ability to measure weather return parameters from a Gaussian random process weather model in the presence of two different clutter models. Clutter model A is a Gaussian random process with a Gaussian spectrum centered at zero mean velocity. The clutter root mean square (rms) spectrum width is the rms of $0.1\ ms^{-1}$ plus the rms spectrum width resulting from the antenna rotation rate at the lowest two elevation angles. Clutter Model B represents a scattering echo from a point target and consists of a complex waveform with an amplitude envelope which is an approximation of the two-way antenna pattern.

3.7.2.7.1 Ground Clutter Suppression Requirements

The RDA shall (1) provide ground clutter suppression capability of at least 30 dB in the reflectivity channel. The RDA shall (2) provide ground clutter suppression capability for the Doppler channel which meets the requirements shown in Table 3-17 for mean radial velocity (V) and spectrum width (W). In areas where the clutter suppression is not applied, there shall (3) be no degradation in the weather return parameter measurement accuracy with respect to sections 3.7.2.2.3.1 and 3.7.2.2.3.2.

For testing purposes, the following shall (4) apply:

a. Ground clutter suppression performance is measured at a nominal frequency of 2.8 GHz.

b. Ground clutter suppression requirements are met when implemented for the lowest two elevation scans on both scan strategies 1 and 2 (see Appendix I).

Table 3-17 CLUTTER SUPPRESSION REQUIREMENTS FOR MEAN RADIAL VELOCITY AND SPECTRUM WIDTH ESTIMATES

	Required Ground Clutter Suppression Capability (I) in dB (Spectrum Width = 4 ms^{-1})	
Minimum Usable Mean Radial Velocity, V_{min} in ms^{-1} (see Section 3.7.2.7.2)	**Clutter Model A**	**Clutter Model B**
2	20	20
3	28	30
4	50	50

If clutter suppression is accomplished by a linear time invariant filter followed by a conventional weather return parameter estimation process such as a pulse pair algorithm, the clutter rejection performance is the ratio of filter input power to filter output power for each of the two clutter models, as illustrated in Figure 3-3. The window time duration shall (5) correspond to the appropriate weather parameter estimation interval.

x(kTs)---- Linear Time Invariant Filter ----Y(kTs)

Clutter Time Series — Output Time Series

Ts = Pulse Repetition Time

Clutter Model	**Algorithm for Computing Clutter Suppression Capability: I**
A	$I = 10\log_{10}\left(\left\langle \left\| x(kT_s) \right\|^2 \right\rangle \Big/ \left\langle \left\| Y(kT_s) \right\|^2 \right\rangle \right)$
B	$I = 10\log_{10}\left(\left\langle \max\left(\left\| x(kT_s) \right\|^2 \right) \right\rangle \Big/ \left\langle \max\left(\left\| Y(kT_s) \right\|^2 \right) \right\rangle \right)$

$\langle\ \rangle$	Represents the value of the time average over a moving window as the antenna scans past a point target. The scan rate assumed should be that used on the lowest two elevations.
$\|\ \|$	Represents absolute value.

3.7.3.4.16 Clutter Suppression Control

The capability to control the application of clutter filtering to include clutter suppression region definition, notch width selection, and bypass map editing, shall (1) be provided.

A minimum of 4 files for defining clutter suppression regions shall (2) be stored in adaptation data.

Each file shall (3) allow for a minimum of 15 clutter suppression regions.

Legacy Clutter Mapping

Legacy clutter mapping is a laborious project, taking at least 2 hours. The antenna stops on each 0.7° radial (512 radials per 360°) to collect data. Along the radial, it uses 1km bin spacing, and using PRF 1 (318 to 326), its range varies from 459km to 471km. For most sites the max range will be 467km (PRF set C, 322). At each radial we

gather 2 sets of data, one with clutter filtering enabled (and at the default notchwidth) and one with clutter filtering disabled. Each set of radial data is 50 pulses wide, so that we gather a total of 100 pulses for each radial. . It combines the 0.7° into 1.4° radials for the clutter map using the scheme shown in Figure 1, Legacy Clutter Mapping, where A and B are output radials.

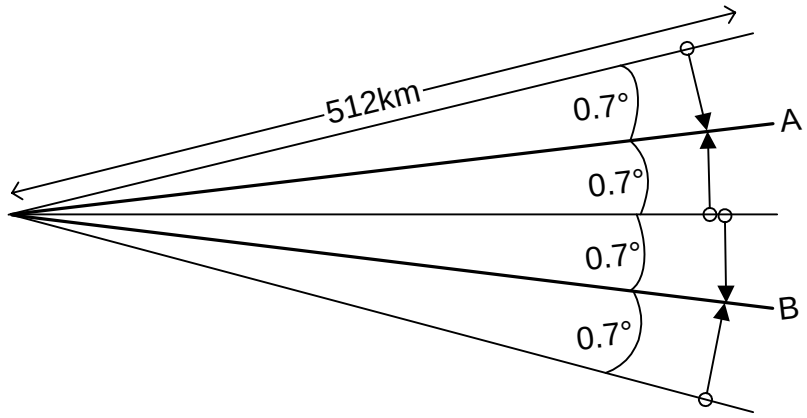

Figure 1, Legacy Clutter Mapping

For each bin of each radial, there is only 1 bit set, a 0 if no clutter is present, and a 1 if clutter is present. These bitmaps are what are or'd together for each cut. There are 2 levels of clutter mapping. All the cuts in each mapping level are and'd together to determine if there is clutter in a bin. These 2 maps comprise the default clutter map.

Because the legacy clutter filter is an IIR filter with persistence and a settling time, each bin at the same range in the map must have the same notchwidth. It does allow up to 8 notchwidth changes through 360°, but this does affect the clutter filter.

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The new clutter filter is a GMAP filter, based in the frequency domain. It does not have persistence and does not require settling time to produce accurate results. It also does not have the same concept of notchwidth as an IIR filter has. It does need a "seed" value of spectrum width, we will use $0.28ms^{-1}$ as our default.

For each clutter map level, we will provide 2 angles, each done with a low PRF to provide clutter mapping to max range. The map will be done on 1° radials with the antenna turning to both speed the process and match normal processing conditions. The antenna speed is slow enough to prevent biasing the spectrum width for clutter detection. Table 1 assumes WSR-33D median wavelength of 10.46cm (2.866Ghz), true clutter width of 0.28m/sec, and median two-way half-power beamwidth of 0.65°.

PRF (hz)	Antenna Speed (°/sec)	Dwell (pulses)	Range (km)	Nyquist (mi/hr)	Spectrum Width (m/sec)
322	.5	108	467	19	0.2837

At 0.5°/sec, it will take approximately 8 minutes to create a clutter map.

The following chart shows the effect antenna motion has on spectrum width. For WSR-88D, a spectrum width of 0.28m/sec is assumed for clutter.

Antenna Speed	deg/sec	deg/sec	deg/sec	deg/sec	deg/sec	deg/sec
True Width	0.1667	0.5	1	2	3	4

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0.1	0.100032	0.100287	0.101141	0.104491	0.109846	0.116932
0.2	0.200016	0.200143	0.200573	0.202283	0.2051	0.208981
0.28	0.280011	0.280102	0.28041	0.281635	0.283665	0.286484
0.3	0.300011	0.300096	0.300382	0.301527	0.303424	0.306061
0.4	0.400008	0.400072	0.400287	0.401146	0.402574	0.404565
0.5	0.500006	0.500057	0.50023	0.500917	0.502062	0.50366
0.75	0.750004	0.750038	0.750153	0.750612	0.751376	0.752445
1	1.000003	1.000029	1.000115	1.000459	1.001033	1.001835

Legacy Clutter Mapping has some other weaknesses, too. The criteria for creating a clutter map are not in the Technical Manual. After creation of a new clutter map, there is no defined way to determine how good the map is.

RPG changes to clutter map control:

- No notchwidth map
- Only 1 map to change
- No Censor Zone map